

Fig 1

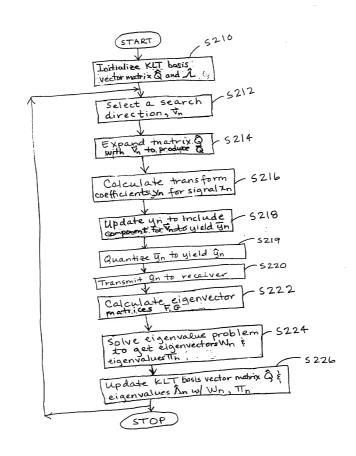
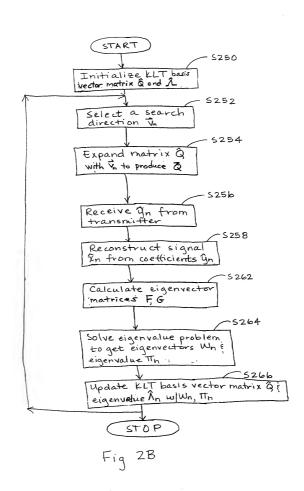


Fig 2A



transmitter	receiver
Qo = In(:,1:r)	Q = IN(:,1:r)
Ĉ₀= Ir	Â, = Ir
for n=1,2,	for n=1, 2,
Qn = [Q̂n-1 Yn]	Qn = [Qn-1 4]
ν <sub>n</sub> = Ĝ <sub>n-1</sub> × <sub>n</sub>	wait for ŷn
$\overline{y}_n = [y_n^T \ x_n^T v_n]^T$	$\hat{\chi}_n = \hat{Q}_{n-1} \hat{y}_n(1:r)$
$\hat{y}_{n} = \Delta(\hat{y}_{n})$	F= YQTQ n ,
transmit ŷn to receiver	G = \$\overline{Q}_{n}^{\overline{Q}_{n}}\$
F = Y Q , Q , _ , _ , Q , _ , Q , + ŷ , ŷ ,	solve FW = GWnTIn for Wn, TI
	Qn = Qn Wn(:,1:r)
G = QTQ Solve FWn = GWnTTn for Wn TTn	$\hat{\Lambda}_{-} = TL(1:r, 1:r)$
	end
$\hat{\mathbb{Q}}_n = \bar{\mathbb{Q}}_n W_n(:, 1:r)$	END
n= Tm(1:r, 1:r)	
end	

Figure 2C

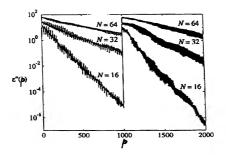


Fig 3

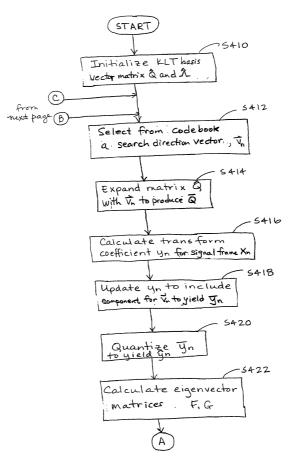


Fig 4A

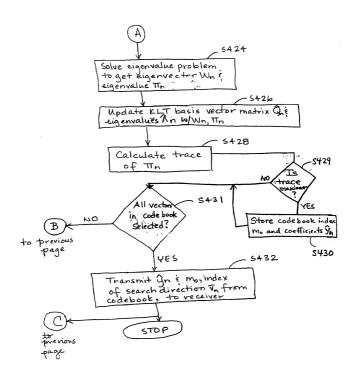


Fig 4A (CONT.)

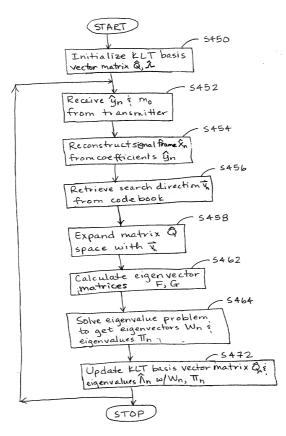


Fig 4B

Figure 4C

```
transmitter
                                                                   receiver
                                                             Q = In(:,1:r)
Q = IN(:1:r)
1 = In
                                                               for n = 1, 2, ...
for n=1, 2, ...
                                                                    wait for In Mo
     Tmax = 0
                                                                     xn = Qn, x (1:r)
       for m=1 ... , M
           V= V(:, m)
                                                                     v<sub>m</sub> = ∇(;, m<sub>0</sub>)
             Q=[Qn vn]
                                                                      Q = [Q ... 4]
             y_n = \hat{Q}_{n-1}^T \times_n
                                                                      F = YQTQ __ _ _ _ _ Q _ _ Q _ + XY _
              J. = [X. x. x.]
                                                                     Ç = ಥ್ನೆಹ್ನ
                                                                      solve FW = GWATT for WATT
              \hat{y}_n = \Delta(\bar{y}_n)
              F = \kappa \overline{Q}^{\mathsf{T}} \hat{Q}_{n-1} \hat{\Lambda}_{n-1} \hat{Q}_{n-1}^{\mathsf{T}} \overline{Q}_{n} + \hat{y}_{n} \hat{y}_{n}^{\mathsf{T}}
                                                                      Q= Q Wn(:,1:r)
              G = Q, Q,
                                                                      An=Th(1:51:r)
               Solve FWn = GW,TTn for Wn, Tn
                                                                 end
               Q = Q W (:1:r)
               ~ = TTn (1:17,1:17)
               T = trace (Tr. (1:r, 1:r))
               if T>Tmax
           end

ŷn=ŷn*

transmit ŷn, mo to receiver
```

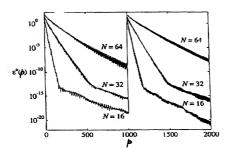


Fig 5

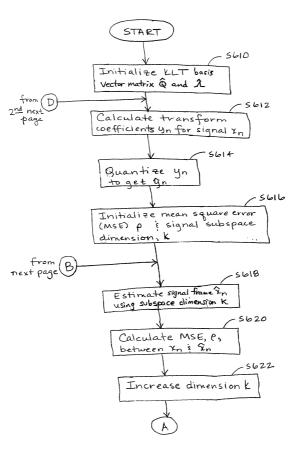
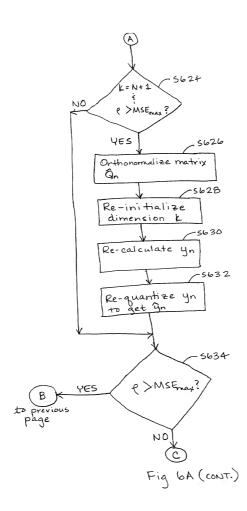


Fig 6A



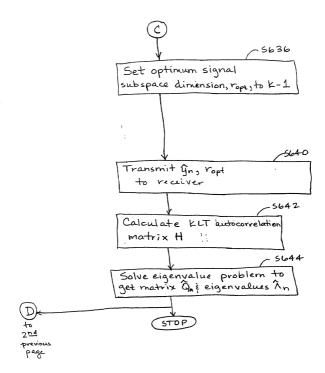


Fig 6A (CONT.)

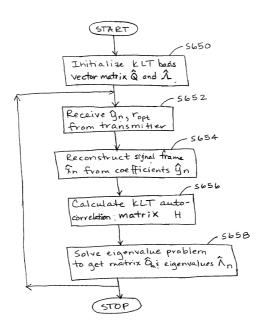


Fig 6B

```
transmitter
                                                       receiver
                                                  Q = In
Q = IN
Â= IN
                                                  NI = IN
for n=1,2, ...
                                                   for n=1, 2, ...
                                                        wait for ŷn (1: Pope), Pope
     y_n = \hat{Q}_{n-1}^T X_n
                                                        \hat{X}_n = \hat{Q}_{nel}(:, : r_{opt}) \hat{Y}_n(: r_{opt})
     \hat{y}_n = \Delta(y_n)
                                                         H= 82 + 9 9 9
     P=1
      .
K=1
                                                         Solve HQn = Qn Anfor
      while p > MSEmox
                                                    end
           xn = Qn-1(:,1:K) xn(1:K);
            p= || xn - xn ||2/ || xn ||2
            K= K+1
             if K=N+1 and p>MSEmax
                 orthonormalize columns of Q
                  yn = QT xn
                  \hat{\chi} = \Delta(y_n)
       end
       transmit In(1: ropt), topt to receiver
        H= 8Ân+ + ŷnŷt
Solve HQ= Q,Ân for Q,Ân
   end
```

Figure 6C

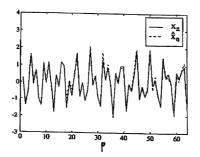


Fig 7

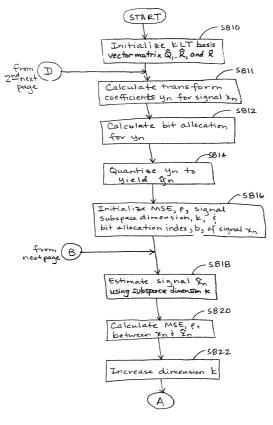
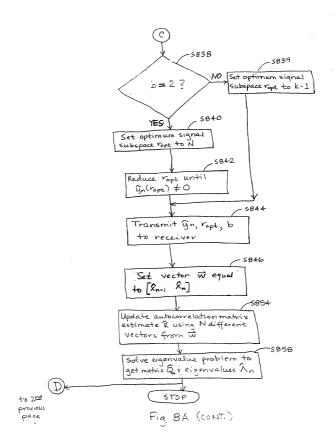
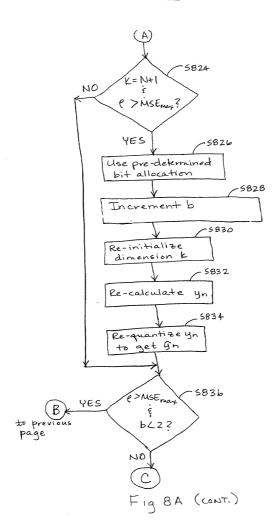


Fig 8A





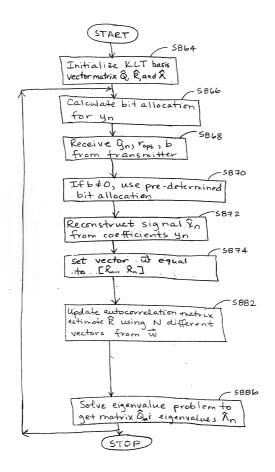


Fig 8B

## Figure 8C

transmitter
:o = In
દ્રે = ⊙
= βIn
for n=1, z,
x = Q x
$\hat{y}_n = \Delta(y_n)$
p=1 K=1, b=0
while p>MSEmax and b<2
$\widehat{X}_n = \widehat{Q}_{n-1}(i, 1:k) \widehat{y}_n(1:k)$
$\rho = \ \hat{\mathbf{x}}_{n} - \mathbf{x}_{n}\ ^{2}$
k= K+1
if K=N+1 and p>MSEmax
use alternative bit allocation
b=b+1, k=1 >n=Q <sup>+</sup> , xn
$\hat{y}_n = \Delta(y_n)$
end
if b + 2, root = K-1
if b=2
Topt = N
reduce rope until yn(ropt) # 0
transmit Sn(1: ropt), ropt, b to receiver
$\omega_{n} = \begin{bmatrix} \hat{x}_{n-1}^{T} & \hat{x}_{n-1}^{T} \end{bmatrix}^{T}$
Rn-1,0 = Rx-1
for m=1N
$z = W_n(m+1:m+N)$
$\hat{R}_{M-1,M} = \hat{\nabla} \hat{R}_{M-1,M-1} + 2z^T$ end
R= R M
solve R. a. = â. A. for Q, A.

## receiver

$$\begin{split} \widehat{Q}_o &= I_N \\ \widehat{X}_Q &= Q \\ \widehat{R}_o &= \beta I_N \\ \text{for } N &= 1, 2, \dots \\ \text{wait for } \widehat{Y}_n, r_{opt}, \text{ and } b \\ \text{if } b \neq 0, \text{ use alterative bit allocation} \\ \widehat{X}_m &= \widehat{Q}_m \widehat{Y}_n \\ W_m &= \left[ \widehat{X}_{m-1}^T \widehat{X}_m^T \right]^T \\ \widehat{R}_{n-1}^T &= \widehat{R}_{m-1}^T \\ \text{for } m &= 1:N \\ &= W_m(m+1:m+N) \\ \widehat{R}_{m-1}^T &= W_m(m+1:m+N) \\ \widehat{R}_{m-1}^T &= \widehat{R}_{m-1}^T \\ \text{end} \\ \widehat{R}_m &= \widehat{R}_{n-1}^T , N \\ &= \text{Solve } \widehat{R}_n \widehat{Q}_m = \widehat{Q}_n \widehat{A}_m \text{ for } \widehat{Q}_n \widehat{A}_m \\ \text{end} \end{aligned}$$

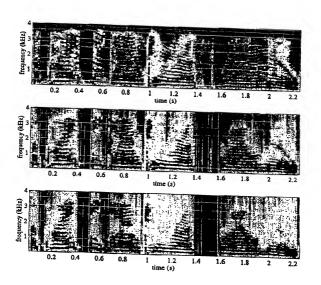
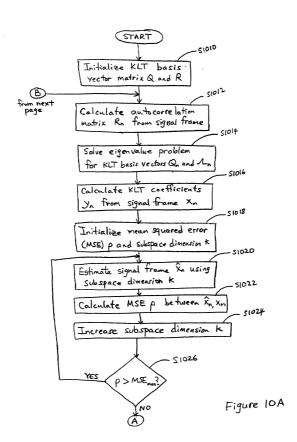


Fig 9



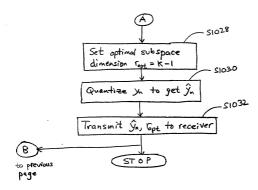
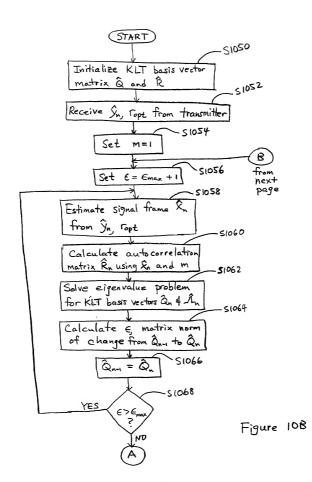


Figure 10A (cont)



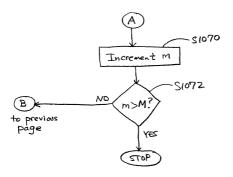


Figure 10B (cont.)

```
transmitter
                                               receiver
                                            Q=I
Qo=IN
                                             Ro = BIN
Ro=AIN
                                             for n=1,2,...
for n=1, 2, ...
                                                 wait for In rope
     R_n = \forall R_{n-1} + x_n x_n^T
     Solve Rnan = andn. for andn
                                                  for m = 1,... M
     1 = Q X
                                                      € = €max + 1
      p=1
                                                       while E>Emax
                                                         2 = Q(:,1: " (1: 13,2)
      k=1
      while p> MSEmax
                                                         if m=1
          2 = Q, (: 1:K) y, (1:K)
           P = 11 2 - x112/1x112
                                                              -
| R = R + ~ X X X T
            K= K+1
                                                          end solve RnQn = Qnln for Qnl
       end
                                                           €= || Q_- Q_- ||
       Topt = K-1
                                                          Q = Q.
       \hat{y}_n = \Delta(\hat{y}_n)
                                                      end
       transmit In, ropt to receiver
                                                   end
                                               end
  end
```

Figure 10c

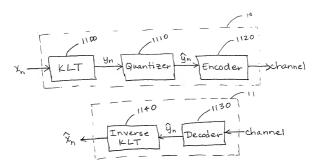


Fig. 11